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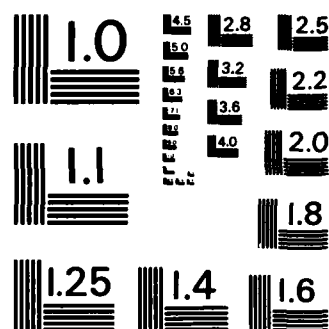UNCLASSIFIED   DEC 85 N66314-70-A-0083   F/G 13/2   NL

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DEVELOPMENT of TASK STATEMENTS
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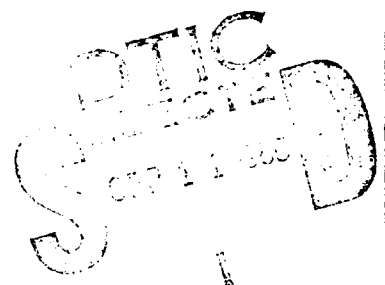
The Graduate School

N66314-70-A-00P3

Development of Task Statements and Standards

for

Water and Wastewater Treatment Plant Maintenance

A Report in

Environmental Engineering

By

Roland S. MOREAU

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Master of Engineering

December 1985

We approve the report of Roland S. Moreau

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INTRODUCTION

The supply of safe potable water and the proper treatment and disposal of the resultant sewage are services that impact everyone. Consequently, costs for construction, operation, and maintenance of the necessary treatment facilities are borne by all who receive service, either directly or indirectly. Construction costs usually are funded through government grants and bonding. Competitive bidding and agency overviews tend to keep those costs under control without limiting them unduly. However, costs of operations and maintenance usually are the responsibility of the local owner (ie. authority, municipality, etc.) and normally are funded through service charges assessed to the consumers. Without a rigid system in place to dictate operations and maintenance levels, the only forces acting on the owners generally are those of the consumers, ie. a desire for the lowest possible rate.

Webster states that maintenance is the upkeep of property and equipment in a state of efficiency. Looked at in another way, maintenance is the act of keeping property and equipment in the same condition it was yesterday. That

definition is the crux of the problem, as there is little evidence that the work

that has been accomplished justified the expenditures made. The rate of

deterioration is often times slow enough that deferral of maintance can be an

accepted course of action for many years. The incidence of breakdowns and

process interruptions gradually increases to the point that major overhaul or

replacement is necessary. The irony of the situation is that the manager of

the facility during the period of deferred maintenance is very highly thought

of because of his success in keeping current operating costs down. Higher

level management does not realize that, in actuality, he is consuming their

capital investment by deferring maintenance expenditures.

The function of management is to obtain the most return for the least

investment. Normally, the only costs included in the equation are those that

are experienced during the fiscal calendar. Deferred maintenance is not

included unless there has been a conscious effort to quantify its value.

However, the oil filter advertisement that said "you can pay me now or pay

me later" is very true. The deferred maintenance costs will be paid

eventually, and probably at a very high rate.

The purpose of this paper is to develop a series of labor hour standards

that can be applied to maintenace and repair actions on water and wastewater treatment plant equipment.   Through application of the appropriate standards, a manager will be able to estimate the yearly cost of maintenance (both preventative and corrective) for his facilities.   The system developed as part of this project will provide documentation that can be used to justify budget requests, staffing, and quantify the impact that deferred maintenance will have in future budgets.   The standards also can be used to evaluate employee efficiency and identify deficiencies in supervision and training that otherwise would go unrecognized.

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LITERATURE REVIEW

A review of the literature has revealed no published standards for the maintenance and repair tasks that are developed later in this paper. There is substantial evidence in the literature to indicate that maintenance and repair has not been sufficient to maintain plants in many cases. The national desire to have clean rivers, lakes, and streams has resulted in massive programs to build treatment plants that are designed to remove contaminants from waste streams prior to discharge into a receiving body of water. The Government Accounting Office has reported that, as of December 1979, almost 18,000 plants, representing a federal government investment of 25 billion dollars and several billion dollars more from State and local governments, were in operation or under construction.[1] This huge investment in capital by Federal and State governments in futherence of National policy has been turned over to local municipalities and sewer authorities to maintain and operate. By the late 1970's, it was becoming obvious that an increasing number of treatment plants were failing to perform as expected. In a white paper on operation and maintenance of water pollution control facilities, the Water Pollution Control Federation (WPCF) found that emphasis in this area had

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been greatly overlooked in the haste to get waste treatment systems in place and on-line.[2] They recommended that owners should require a realistic updated cost of operations and maintenance from the design consultant both at the time 50 percent of the construction is completed and prior to the last budget cycle before the system is ready for operation.[3]

In a comprehensive study by EPA of 103 facilities, a total of 70 potential problem areas (10 of which were maintenance) were weighed and ranked for severity of impact on performance.[4] While a maintenance factor was the leading cause of poor performance in only one plant, it was a contributing factor noted in at least twenty percent of the plants studied. One of the recommendations made as a result of the study was that budgeting for operation and maintenance of wastewater treatment facilities must become organized and a higher priority in municipal budgets.[5]

The AWWA Committee on Job Measurement Standards reported on the methods and benefits of applying standards to water utilities operations in 1979.[6] They gave no actual standards to use, but described methods to be used for development of standards. The report did indicate that the benefits to be gained by using standards included increased productivity, better collection of cost data, and discovery of new work methods. Productivity

was improved because management was able to effect better coordination, maintain continuous operations and obtain better utilization of the available manpower. Better collection of cost data and discovery of new work methods resulted from comparison of actual work to estimated work.

There is much evidence to support the theory that improved management of maintenance can save money. As early as 1971, the City of Philadelphia Water Department instituted a systemized approach to maintenance with time standards and found an annual savings in excess of $318,000 after two years.[7] An outside consultant was hired to develop time standards that were tailored to their plant. Both the Los Angeles County Flood Control District[8] and Colorado Springs[9] found that new maintenance management systems have been instrumental in reducing maintenance budgets without reducing services or output. The City of Wausau, Wisconsin found that, by hiring a professional firm to operate the plant and schedule maintenance, it was able to reduce down time and end a series of permit violations.[10] Industry also has found that maintenance management is important. A metal processing facility[11], Monsanto and Chemplex chemical plants in England[12], and Corning Glass Works[13] have all found that, by installing maintenance management systems, costs and equipment down times are reduced.

There has been some concern that, with the improved maintenance management systems being implemented, it is possible to go overboard and expend funds performing unnecessary maintenance. It has been reported that an increased level of maintenance should reduce the costs incurred due to failure.[14] However, there is a point where a higher level of maintenance does not result in a proportionate reduction in the costs due to failure and total expenditures start to rise. Figure 1 graphically depicts the relative relationship. The level of maintenance is based on the frequency of maintenance. More frequent accomplishment of preventive maintenance work, such as greasing and oil checks, is considered a higher level of maintenance. As tasks are performed more frequently, the cost to accomplish the maintenance rises, but the likelihood of failure of the component will decrease. The costs due to failure decrease rapidly as the level of maintenance is increased from zero to the manufacturers recommended levels. Beyond that point it levels out. When both maintenance costs and costs due to failure are added for a given level of maintenance, it can be seen that there is a level of maintenance that will minimze costs. Instrumentation equipment may be a type that is likely to be subject to over maintenance.[15,16]

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FIGURE 1
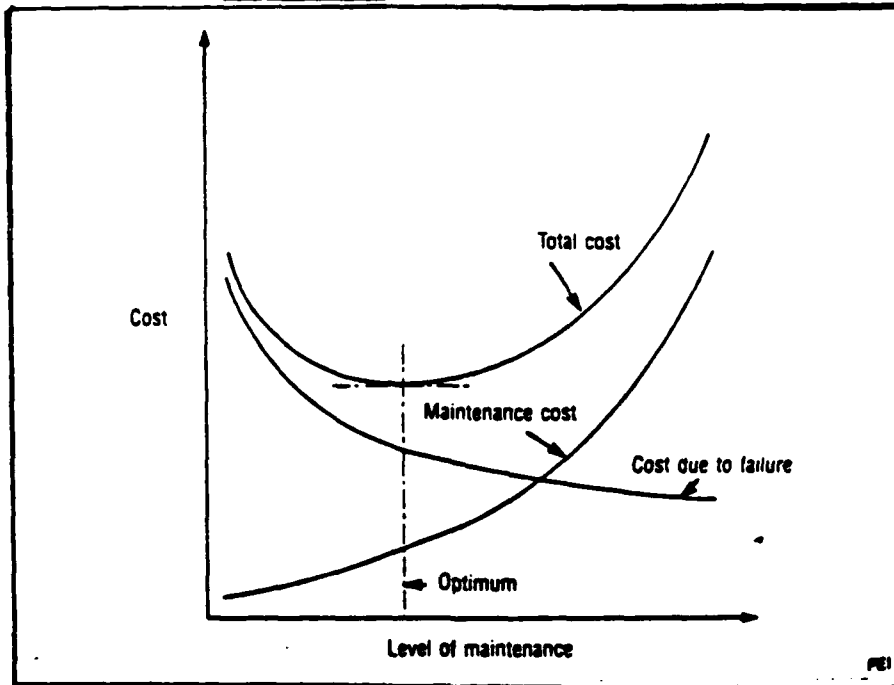
Relation of Costs to Maintenance Levels

from Petroleum Engineer International[14]

CONCLUSIONS

The purpose of this work was to develop a list of task statements that could be used by water and wastewater treatment plant managers to assist in setting maintenance budgets and determining staffing. A list of task statements has been presented and estimated labor hours and frequencies provided for many of the task statements. There is a serious need for an industry accepted set of standards for labor hours and frequencies. The numbers developed herein are a start, but much more work is necessary before they will be accepted as fact. The main impediment to this happening is not a lack of need, as most every computerized system requires that type of information in order to implement an effective maintenance system. What is needed, is a coordinated effort by one of the professional organizations in the field. It is recommended that a project similar to the Operations and Maintenance White Paper produced by the WPCF be conducted.[17] The methodolgy and results presented herein can be used to expand the data base and, ultimately, accomplish the goal initially established. It is anticipated that more information will be available within the next two to five years because there are many automated maintenance management systems

major factor influencing frequencies is the presence or lack of standby units.

If there are standby units and the "on" unit is rotated periodically, then

repair and replacement frequencies will be much different from normal.

Other major influences on frequency of task accomplishment are exposure to

weather, quality of craftmen, quality of preventive maintenance, and

suitability of the equipment for the application. The computer data base

used has a provision for developing high and low factors that can be applied

to the average frequency values, but this adjustment was not accomplished

during this project because it would require a fairly substantial data sample

to have meaningful results. There was very little information of this nature

available at the time the study was conducted.

has seized to the shaft. Obviously, the necessary time to perform the task will be quite different in each case, but neither will be the same as the standard. The advantage of having standards is that they will provide an indication that further investigation is necessary. In some cases, the individuals may not be performing tasks as quickly as they should and more supervision or training may be necessary. In other cases, it may be a maintenance system that allows bearings to freeze to shafts that needs improvement. By using a system of standards, a good manager should be able to easily identify problems and thereby correct them sooner.

The EPS manuals that were used to determine labor hours for most of the task statements provide labor hour estimates with too many significant figures. Most tasks should be estimated to the nearest minute or five minutes and not to the nearest 0.36 second as is done in the manuals. The data input to the computer have been rounded off to the nearest 0.001 hour, but it is recognized that in actual practice standards probably will be written to the nearest 0.1 hour.

The frequencies that have been determined are average times for the particular task statement. Frequencies are very difficult to estimate because there are so many factors that have an effect on the values. The

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DISCUSSION

The task statement outline, Appendix B, is not all inclusive. For some

of the components (ie. pumps), the tasks listed are comprehensive and

include almost all actions that would be necessary during the life of a

component. However, for other components (ie. some of the sludge handling

equipment) there is very little information available and many components

have become prematurely obsolete due to changes in operating factors such

as energy costs. There are some components where the only tasks listed are

preventive maintenance, repairs, and replacement as no more detailed task

statements could be determined. The list of tasks provided is as

comprehensive as possible based on the information that is currently

available.

Veteran mechanics or electricians may feel that the labor hour

estimates do not provide enough time to perform the task. The estimates

may seem low because they are average craft times and do not include time

to get to the job site, go for parts or materials, and trouble shoot. Actual

times to perform the tasks can vary dramatically depending on the conditions

the craftsman is confronted with. As an example, a bearing may be removed

quickly if it is just starting to go bad, but it may have to be torched out if it

FIGURE 3

TASK DATA FORM

Task Code: __0811101__

Component: __TANK-LESS WATER CLOSET__   System: __SANITARY__   Subsystem: __FIXTURES__
Task Description: __REPLACE FLUSH VALVE__
Unit of Measure: __M/R__   Frequency of Occurrence: H: __8.00__ A: __10.00__ L: __12.00__
Persons per Team: __1-CT__   Task Duration: __0.117__   Trade: __3__
References: Labor: __2__   Material: __1__   Equipment: __1__

Labor Resources

Subtask Description	Labor Hrs
REMOVE OLD FLUSH VALVE	
INSTALL NEW FLUSH VALVE (QT-311 TWICE).	0.090

Material Resources

Description	Quantity	Unit Cost	Total Cost	Equiv Labor Hrs
Material	0.00	0.00	0.11	0.0082
	0.00	0.00	0.03	0.0020

SUMMARY

Resources	UOM	Direct	Indirect	Total
Labor	LH	0.090	0.027	0.117
Material	ELH	0.010	0.003	0.013
Equipment	ELH			0.117

Components Containing This Task: _____

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Figure 2

NT-198   REMOVE AND INSTALL MOTOR FROM CENTRIFUGAL SUMP PUMP. REMOVE AND INSTALL PUMP SHAFT PACKING, SHAFT BEARING, SHAFT OR IMPELLER IN SHOP. MOVING PUMP TO SHOP NOT INCLUDED.

NO	REFERENCE	WORK UNIT DESCRIPTION	HOURS	UNITS	V38
1	PWMU-1-8000	REMOVE 4 SCREWS FROM SWITCH COVER PLATE.	.03508	JOB	
2	PWMU-1-8005	REMOVE SWITCH COVER PLATE.	.00198	JOB	
3	PWMU-1-8006	DISCONNECT WIRES AT 3 TERMINALS.	.02013	JOB	
4	PWMU-1-8000	REMOVE 2 SWITCH BRACKET SCREWS.	.01754	JOB	
5	PWMU-1-8010	REMOVE SWITCH ASSEMBLY.	.01265	JOB	
6	PWMU-1-8013	REMOVE FLOAT ROD SPRING RETAINER PIN.	.02252	JOB	
7	PWQ-19-I	UNSCREW MOTOR FROM PUMP TUBE.	.06763	JOB	
8	PWMU-1-8021	INSERT FLOAT ROD THROUGH MOTOR END BELL GUIDE HOLE AND FLOAT ROD SPRING.	.02412	JOB	
9	PWMU-1-8010	INSTALL SPRING RETAINERS OVER FLOAT ROD END.	.02530	JOB	
10	PWMU-1-8010	ENGAGE SPRING COUPLING WITH SLOT IN MOTOR SHAFT.	.01265	JOB	
11	PWQ-19-I	SCREW MOTOR ON TO PUMP TUBE.	.06763	JOB	
12	PWMU-1-8013	INSTALL FLOAT ROD RETAINER PIN.	.02252	JOB	
13	PWMU-1-8010	INSTALL SWITCH ASSEMBLY.	.01265	JOB	
14	PWMU-1-8000	INSTALL 2 SWITCH BRACKET SCREWS.	.01754	JOB	
15	PWMU-1-8006	CONNECT WIRES AT 3 TERMINALS.	.02013	JOB	
16	PWMU-1-8005	INSTALL SWITCH COVER PLATE.	.00198	JOB	
17	PWMU-1-8000	INSTALL 4 COVER PLATE SCREWS.	.03508	JOB	
18	PWMU-1-8013	REMOVE IMPELLER SHAFT DRIVE PIN.	.02252	JOB	
19	PWMU-1-8000	LOOSEN IMPELLER SHAFT COUPLING ADAPTER COLLAR SET SCREW.	.00877	JOB	
20	PWMU-1-8000	REMOVE IMPELLER SHAFT COUPLING ADAPTER COLLAR.	.00877	JOB	
21	PWMU-1-8000	REMOVE 4 SCREWS ON PUMP BASE TO PUMP HOUSING.	.03508	JOB	
22	PWMU-1-8005	REMOVE PUMP BASE.	.00198	JOB	
23	PWMU-1-8000	REMOVE 4 PUMP HOUSING PLATE SCREWS.	.03508	JOB	
24	PWMU-1-8010	REMOVE PUMP HOUSING PLATE.	.01265	JOB	
25	PWMU-1-8011	REMOVE IMPELLER SHAFT AND IMPELLER, SHAFT ADAPTER AND IMPELLER SHAFT BELL BEARING.	.03618	JOB	
26	PWMU-1-8000	REMOVE PUMP BEARING.	.00877	JOB	
27	PWMU-1-8013	REMOVE PUMP BEARING PACKING GLAND RETAINER.	.02252	JOB	
28	PWMU-1-8010	REMOVE PUMP BEARING PACKING GLAND.	.01265	JOB	
29	PWMU-1-8005	REMOVE PUMP BEARING PACKING, SPRING AND WASHER.	.00594	JOB	
30	PWMU-1-8005	ASSEMBLE PUMP BEARING PACKING GLAND WITH NEW PACKING (4 RINGS), SPRING AND WASHER.	.01188	JOB	
31	PWMU-1-8010	INSTALL PUMP BEARING PACKING GLAND AND RETAINER INTO BEARING.	.02530	JOB	
32	PWMU-1-8000	INSTALL PUMP BEARING INTO PUMP TUBE.	.00877	JOB	
33	PWMU-1-8013	REMOVE IMPELLER PIN.	.02252	JOB	
34	PWMU-1-8013	REMOVE IMPELLER FROM SHAFT.	.02252	JOB	
35	PWMU-1-8013	ASSEMBLE IMPELLER, IMPELLER SHAFT AND IMPELLER PIN.	.04504	JOB	
36	PWMU-1-8013	INSTALL IMPELLER SHAFT INTO PUMP TUBE.	.02252	JOB	
37	PWMU-1-8010	INSTALL IMPELLER SHAFT BALL BEARING RETAINER.	.01265	JOB	

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Example of Engineered Performance Task

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directly listed. Estimates were developed by using the estimated times for similar actions. The EPS manuals list a task and time and then break the time estimate into the several steps (each individually estimated) necessary to complete the task, see Figure 2 for an example. In many cases, all steps in the EPS task were not needed for the task statement being estimated, but the author was able to apply some of the steps to a water and wastewater task statement to develop an estimate. There is a memo field in every record in the data base that details and references how the estimated labor hours, frequency, equipment, or materials were determined. After all the information possible was gleaned from the EPS manuals, other sources were used to estimate labor hours. The author was not able to estimate labor hours for every task listed because the information necessary to accomplish this effort was not available. Frequencies for some of the task statements were estimated and documented in the same manner that the labor hours were done. However, due to lack of time, only approximately 10 percent of the task statements had frequencies estimated and no material or equipment estimates were developed. A sample task statement data form is shown in Figure 3.

estimated labor hours, equipment, or materials for any of the tasks and there

are no industry accepted standards on the life expectancy of equipment.

Letters were sent to firms that provide automated maintenance systems; a

sample letter is included in Appendix D, but no firm was able to list a

reference that had been using its system long enough so that they considered

their data to be of any value for use in this project. Most firms responded

that their systems were new and had not been put in place yet.

Labor hours were selected as the first parameter to study in detail.

Rather than trying to determine every unknown for every task statement, if all

labor hours were estimated at once there would be more consistency and

efficiency in providing this information. Labor hours for each task were

estimated using several sources for guidance, a list of which is provided in

Appendix E. The reference number for each source listed in Appendix E is the

labor reference noted in the task statement record in the computer data base.

Most of the estimates were developed using one or more of the Engineered

Performance Standards (EPS) manuals written by the Department of Defense.

See Appendix E for a list of the specific manuals used. These manuals were

designed to aid in estimating labor hours for maintenance and repair of DOD's

real property (buildings and grounds). There were very few tasks that were

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There are more than six hundred task statements for the water and wastewater treatment plants. It would be very time consuming and tedious to keep track of all the information required without the use of a computerized data base. For this project, a relational data base called D-Base III by Ashton-Tate, Inc. was used. A routine developed by the Architectural Engineering Department of the Pennsylvania State University for the CERL project on plumbing and electrical systems was modified for use in this project. The routine develops reports in the format that CERL requires, but is flexible enough to allow output in a variety of formats. The computer used was an IBM-PC/XT with a 10 megabyte hard disk. Appendix C lists the directions for use of the system including input and output of data.

c. Frequency and Labor Hour Estimates.

For each task statement, the ultimate goal is to have an estimate for the labor hours, equipment, and materials necessary to accomplish the task and frequency of occurence of the task. The only data the author found readily available for the tasks on water and wastewater treatment equipment were that for frequency of preventive maintenance. There are no published data on

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the Army Civil Engineering Research Laboratory (CERL), the financial sponsor

for this project. The first four digits refer to the type of treatment plant, ie.

1616xxx is for water treatment plants and 1624xxx is for wastewater

treatment plants. The fifth digit refers to the unit operation. The numbers

one through nine were used for this, the sixth, and the seventh digits. The

number zero was not used to avoid confusion in submittals to CERL. Because

there were more than nine unit operations, after the number nine, letters were

used sequentially starting with "A" and going to "Z". Letters were allowed to

be used in any digit and were needed with most of them. The sixth digit refers

to the component and values were assigned sequentially as the components

were determined for the unit operation under study. Because of the number of

components, it was not possible to always list motors as "1" and centrifugal

pumps as "2", for example. The seventh digit refers to the task statement.

Readers should note that the there are what may appear to be missing task

statements in Appendix B. These appparent omissions were proposed tasks

that were deleted during the study for lack of applicability. This numbering

system is somewhat cumbersome to use and does not allow for grouping by

level of treatment, ie. primary, secondary, tertiary, etc., but was used because

it was mandated by the project sponsor.

as motors, that are used in many different unit operations. They were listed only once per unit operation, but were included in every unit operation in which they are found. In this way, a complete list of components can be assembled if the unit operations to be used are known.

Each component listed was analyzed to determine the types of tasks that would have to be accomplished over the life of the component to keep it in operating condition. Sources of information used included manufacturer's maintenance instructions, existing treatment plant operations and maintenance manuals, treatment plant mechanics (through interviews), manuals of practice, and personal inspection of some of the equipment by the author. Two water treatment plants and four sewage treatment plants were visited by the author to conduct interviews with mechanics, review equipment maintenance cards and conduct inspection of equipment. The tasks were compiled into a list on the basis of unit operation. This list is presented in Appendix B.

b. Numbering and Data Base System.

A seven digit numbering system was applied to the list giving each task statement a unique number. The numbering system used was one specified by

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TABLE 1

LIST OF UNIT OPERATIONS TO BE CONSIDERED

WASTEWATER TREATMENT

PRIMARY
   SCREENING
   GRINDING
   FLOW METERING
   PRIMARY SETTLING
   SLUDGE HANDLING
   SCUM REMOVAL

SECONDARY
   AERATION
   AIR DELIVERY
   SECONDARY CLARIFIERS
   CHEMICAL TREATMENT
   RETURN SLUDGE
   EXCESS SLUDGE HANDLING
   SCUM REMOVAL
   CHLORINATION
   EFFLUENT WATER SAMPLING
   EFFLUENT WATER METERING
   TRICKLING FILTER
   ROTATING BIOLOGICAL CONTACTOR EQUIP
   FILTRATION

TERTIARY
   NITROGEN REMOVAL
   PHOSPHORUS REMOVAL

SLUDGE HANDLING
   INCINERATIORS
   VACUUM FILTRATION
   SLUDGE CONDITIONING
   CHEMICAL TREATMENT
   SLUDGE THICKENING
   SLUDGE DIGESTORS
   CENTRIFUGE EQUIPMENT

WATER TREATMENT

   PUMPING EQUIPMENT
   MIXING
   FLOCCULATION
   FILTRATION
   CHLORINATION
   ION EXCHANGE
   ACTIVATED CARBON COLUMN

treatment (Table 1) was compiled. Not all unit operations listed would be encountered in any one plant, but the list is inclusive of unit operations that have been and are being used to treat water and wastewater streams. Two areas that were not included are incineration of sludge and final disposal of sludge , ie. landfilling or spraying on agricultural lands. It was felt that those areas are outside the basic scope of this study.

Each of the unit operations listed was reviewed in detail and any equipment or appurtenance that might be necessary for that operation was listed. For example, under the unit operation called sludge pumping, there were five different types of pumps listed (plunger, centrifugal, rotary, diaphragm, and grinder) because any of these pumps might be used for that purpose. In any one plant handling sludge, there often would be only one type of sludge pump installed, but that particular pump could be any of the five listed types depending on the characteristics of the sludge, volume of flow, head, and designer preferences. For the purposes of this study, each of the pieces of equipment and various appurtenances were defined as a component. Appendix A contains a list of the components considered in this study. One may note that there are many components that were listed more than once in Appendix A. That situation occurred because there are some components, such

The goal of this project was to produce a set of labor hour and frequency standards that can be applied to maintenance, repair, and replacement of equipment and appurtenences used in water and wastewater treatment. As indicated in the previous section, a diligent search of the literature revealed no published reports that had accomplished such a task. A list of the tasks to be considered was compiled, a system to number and store the information was developed, and estimates of labor hours and frequency of occurrence were made.

a. Development of a List of Tasks.

Water and wastewater treatment consists of a series of unit operations designed to deliver an effluent with the desired qualities. The most logical way to compile the data is on the basis of unit operations. Different plants will have a different combination of unit operations and vessel sizes depending on the influent characteristics and effluent qualities desired, but the equipment necessary for each unit operation is basically the same.

A complete list of unit operations that are used in water and wastewater

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collecting the data today.

Author's Observations

The Environmental Engineering profession must improve its public image. Much has been said in the technical literature and common press about how poorly treatment plants perform. The public is exposed to this poor record of performance almost daily and it is a black mark on our profession. This paper is an attempt to cause engineers to recognize that operations and maintenance play an important role in the performance of a treatment plant and that much work must be done to improve the management of operations and maintenance. It is the responsibility of all involved in the profession to take that extra step necessary to ensure that treatment plants perform as designed. It is very important that the public believe in the integrity and competence of the professionals in the field.

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APPENDICES

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Appendix A

List of Components

APPENDIX A
LIST OF COMPONENTS

1616000 WATER TREATMENT PLANT

1616100   Pumping

1616110	Centrifugal Pump
1616120	Piping
1616130	Valves
1616140	Pump Motor

1616200   Rapid Mixer

1616210	Chamber
1616220	Mixing Tank
1616230	Mixer

1616300   Flocculation

1616310	Basin
1616320	Flocculator
1616330	Flocculator Motor

1616400   Clarification

1616410	Basin
1616420	Sludge Collector Mechanism
1616430	Sludge Collector Drive
1616440	Sludge Collector Drive Motor

1616500   Filtration, Ion Exchange, Activated Carbon

1616510	Concrete Basin
1616520	Steel Tank
1616530	Underdrain piping
1616540	Rate Control Valve
1616550	Backwash Pumps
1616560	Surface Wash System
1616570	Pump Motor

1616600   Chlorination and Flouridation

1616610	Chlorine Injectors
1616620	Chlorinator
1616630	Pressure Reducing Valve
1616640	Automatic Controls
1616650	Injector Booster Pump

1616700   Sludge Pumping

1616710	Piping
1616720	Pump Motor
1616730	Adjustable Speed Drive
1616740	Centrifugal Pump

1616800   Chemical Feed System

1616810	Storage Bin and Cyclone
1616820	Vibrator
1616830	Screw Dry Chemical Feeder
1616840	Piping
1616850	Agitator/Mixer
1616860	Conveyor
1616870	Motor
1616880	Slaking Tank
1616890	Metering Pump

1624000 SEWAGE TREATMENT PLANT

1624100   Raw wastewater Pumping

1624110	Centrifugal Pump
1624120	Pneumatic Ejector
1624130	Piping
1624140	Sewage Pump Motor

1624200 Comminutation

1624210 Comminutor Motor

1624220 Gear Box

1624230 Cutting Bars and Screen

1624240 Channel

1624300 Screening

1624310 Bars

1624320 Rake Mechanism

1624330 Rake Mechanism Motor

1624340 Channel

1624400 Primary Settling

1624410 Basin

1624420 Sludge Collector Mechanism

1624430 Sludge Collector Drive

1624440 Scum Collector

1624450 Sludge Collector Drive Motor

1624600 Aeration Tank – Diffused Aeration

1624610 Basin

1624620 Air Distribution System

1624630 Air Blower

1624640 Blower Motor

1624650 Air Filter System

1624700 Aeration Tank – Mechanical Aerator

1624710 Aerator

1624720 Aerator Motor

1624730 Basin

1624800 Secondary Clarifier

1624810 Basin

1624820 Sludge Collector Mechanism

1624830 Sludge Collector Drive

1624840 Scum Collector

1624850 Sludge Collector Drive Motor

1624900- Chlorination

1624910 Basin

1624920 Chlorine Injectors

1624930 Chlorinator

1624940 Pressure Reducing Valve

1624950 Automatic Controls

1624960 Booster Pump

1624A00 Sludge Pumping

1624A10 Piping

1624A20 Pump Motor

1624A30 Adjustable Speed Drive

1624A40 Plunger Pump

1624A50 Centrifugal Pump

1624A60 Rotary Positive Displacement Pump

1624A70 Diaphragm Pump

1624A80 Grinder Pump

1624B00 Aerobic Sludge Digestion

1624B10 Basin

1624B20 Air Distribution System

1624B30 Air Compressor

1624640 Compressor Motor

1624B50 Mechanical Aerator

1624B60 Mechanical Aerator Motor

1624C00 Trickling Filter

1624C10 Retaining Structure

1624C20 Distributor

1624C30 Undrain System

<u>1624D00 Rotating Biological Contactor (RBC)</u>

      1624D10   RBC Motor

      1624D20   Belt Drive

      1624D30   Gear Reducer

      1624D40   Chain Drive

      1624D50   Tank Enclosure

      1624D60   Rotating Plastic Media

<u>1624E00 Stabilization Lagoon</u>

      1624E10   Earthen Basin

      1624E20   Concrete Basin

      1624E30   Diffused Air Distribution System

      1624E40   Air Compressor

      1624E50   Compressor Motor

      1624E60   Mechanical Aerator

      1624E70   Aerator Motor

<u>1624F00 Dosing Tank</u>

      1624F10   Tank

      1624F20   Piping

      1624F30   Counter

<u>1624G00 Flow Metering</u>

      1624G10   V-Notch Weir

      1624G20   Float and Cable

      1624G30   Sending/Receiving Transmitters

      1624G40   Totalizer

      1624G50   Recorder/Indicator

<u>1624H00 Automatic Sampling</u>

      1624H10   Tubing

      1624H20   Sampler

1624100 Sand Filtration

    1624110   Backwash Pump
    1624120   Pump Motor
    1624130   Automatic Valve Operator and Valve
    1624140   Surface Wash System
    1624150   Underdrain System

1624J00 Sludge Drying Bed

    1624J10   Piping/Channels
    1624J20   Basin
    1624J30   Underdrain
    1624J40   Sand

1624K00 Anaerobic Digestor

    1624K10   Tank
    1624K20   Tank Cover-Fixed
    1624K30   Tank Cover-Floating
    1624K40   Heat Exchanger
    1624K50   Pressure and Vacuum Relief Valves
    1624K60   Flame Arrestor
    1624K70   Instrumentation
    1624K80   Condensate Trap
    1624K90   Recirculation Pump
    1624KA0   Gas Compressor
    1624KB0   Gas Meter

1624L00 Vacuum Filtration

    1624L10   Sludge Vat
    1624L20   Filter Drum
    1624L30   Filter Cloth
    1624L40   Agitator
    1624L50   Vacuum Pump
    1624L60   Filtrate Pump
    1624L70   Vacuum Control Valve
    1624L80   Sludge Cake Conveyor

1624L90 Motor
1624LA0 Variable Speed Drive

1624M00 Centrifuge

1624M10 Rotating Bowl
1624M20 Rotating Conveyor
1624M30 Variable Speed Drive
1624M40 Motor

1624N00 Filter Press

1624N10 Filter Cloth
1624N20 Filter Plates
1624N30 Frame
1624N40 Closing Gear
1624N50 Motor
1624N60 Sludge Pump
1624N70 Piping

1624P00 Belt Pressure Filter

1624P10 Belt
1624P20 Scraping Blade
1624P30 Drive Mechanism
1624P40 Drive Motor

Appendix B

TASK STATEMENT OUTLINE

1624A44 replace check valve

1624A45 replace piston rings

1624A46 replace v-belts

1624A47 overhaul

1624A50 Centrifugal Pump

    1624A51 lubricate

    1624A52 replace seals and packing

    1624A53 replace coupling

    1624A54 replace v-belts

    1624A55 disassemble and check impeller

    1624A56 replace impeller

    1624A57 replace bearings

    1624A58 overhaul

1624A60 Rotary Positive Displacement Pump

    1624A61 lubricate

    1624A62 disassemble and check rotor clearance

    1624A63 replace rotor

    1624A64 replace coupling

    1624A65 replace bearings

    1624A66 replace v-belts

    1624A67 overhaul

1624A70 Diaphragm Pump

    1624A71 lubricate

    1624A72 disassemble and clean check valve

    1624A73 replace check valve

    1624A74 replace diaphragm

    1624A75 replace compressor air filters

    1624A76 repair air compressor

    1624A77 overhaul air compressor

    1624A78 overhaul pump

    1624A79 preventive maintenance on air compressor

1624A80 Grinder Pump

    1624A81 lubricate

    1624A82 resurface cutters

    1624A83 replace cutters

1624940 Pressure Reducing Valve
    1624941 clean and adjust
    1624942 replace diaphragm
    1624943 replace

1624950 Automatic Controls
    1624951 clean and calibrate
    1624952 replace

1624960 Booster Pump
    1624961 lubricate
    1624962 replace bearings and packing
    1624963 replace sleeve
    1624964 overhaul

1624A00 Sludge Pumping

1624A10 Piping
    1624A11 flush piping
    1624A12 disassemble and rod out
    1624A13 repair leaks
    1624A14 repack valves
    1624A15 replace valves
    1624A16 clean and paint

1624A20 Pump Motor
    1624A21 lubricate
    1624A22 clean, adjust, and calibrate controls
    1624A23 replace controls
    1624A24 replace/rewind motor

1624A30 Adjustable Speed Drive
    1624A31 lubricate
    1624A32 replace seals
    1624A33 replace lubricant
    1624A34 overhaul

1624A40 Plunger Pump
    1624A41 lubricate
    1624A42 replace packing
    1624A43 replace coupling

1624823 replace worn or broken chain link

1624824 replace bearings

1624825 replace worn/broken chain and sprockets

1624826 overhaul

1624830 Sludge Collector Drive

    1624831 replace lubricant

    1624832 lubricate

    1624833 paint

    1624834 replace oil seals

    1624835 replace shear pin

    1624836 overhaul

1624840 Scum Collector

    1624841 replace worn or broken flights

    1624842 replace corroded hopper

    1624843 unplug hopper

    1624844 replace

1624850 Sludge Collector Drive Motor

    1624851 lubricate bearings

    1624852 replace/rewind motor

1624900- Chlorination

1624910 Basin

    1624911 dewater, clean and repair

    1624912 dewater and clean

1624920 Chlorine Injectors

    1624921 disassemble and clean

    1624922 replace piping

    1624923 replace jets

    1624924 overhaul

1624930 Chlorinator

    1624931 clean, inspect and calibrate

    1624932 replace flexible tubing

    1624933 repair leaks

    1624934 replace

1624621 remove from tank, inspect and clean

1624622 repair leaks

1624630 Air Blower

1624631 clean and check pressure relief valve

1624632 lubricate bearings

1624633 replace belts

1624634 paint

1624635 overhaul

1624636 drain, flush, refill oil resevoir

1624640 Blower Motor

1624641 lubricate bearings

1624642 replace/rewind

1624650 Air Filter System

1624651 clean/replace air filter elements

1624700 Aeration Tank - Mechanical Aerator

1624710 Aerator

1624711 lubricate

1624712 repair/replace impellers

1624713 replace bearings

1624714 replace coupling

1624720 Aerator Motor

1624721 lubricate bearings

1624722 replace/rewind motor

1624730 Basin

1624731 dewater, clean, repair cracks & spalling

1624732 dewater and clean

1624800 Secondary Clarifier

1624810 Basin

1624811 dewater, clean, repair cracks & spalling

1624812 dewater and clean

1624820 Sludge Collector Mechanism

1624821 lubricate chain, bearings

1624822 replace worn or broken flights

1624342 replace corroded gates

1624343 clean and flush channel

1624400 Primary Settling

1624410 Basin

1624411 dewater, clean, repair cracks & spalling

1624412 dewater and clean

1624420 Sludge Collector Mechanism

1624421 lubricate chain, bearings

1624422 replace worn or broken flights

1624423 replace worn or broken chain link

1624424 replace bearings

1624425 replace worn/broken chain and sprockets

1624426 overhaul

1624430 Sludge Collector Drive

1624431 replace oil

1624432 lubricate

1624433 paint

1624434 replace oil seals

1624435 replace shear pin

1624436 overhaul

1624440 Scum Collector

1624441 replace worn or broken flights

1624442 replace corroded hopper

1624443 unplug hopper

1624444 replace

1624450 Sludge Collector Drive Motor

1624451 lubricate bearings

1624452 replace/rewind motor

1624600 Aeration Tank - Diffused Aeration

1624610 Basin

1624611 dewater, clean, repair cracks & spalling

1624612 dewater and clean

1624620 Air Distribution System

1624220 Gear Box

      1624221 lubricate

      1624222 change lubricant

      1624223 replace gears

      1624224 replace coupler

      1624225 replace oil seals

      1624226 clean and paint housing

1624230 Cutting Bars and Screen

      1624231 inspect and adjust cutters

      1624232 sharpen cutting bars

      1624233 replace worn cutting bars

      1624234 unclog jammed mechanism

1624240 Channel

      1624241 clean, repair cracks & spalling

      1624242 replace corroded gates

      1624243 clean and flush channel

1624300 Screening.

1624310 Bars

      1624311 repair broken/corroded bar

      1624312 replace bars

1624320 Rake Mechanism

      1624321 lubricate bearings and chain

      1624322 replace bearings

      1624323 replace worn/broken chain links

      1624324 replace worn/broken rake tines

      1624325 repair worn/broken screen

      1624326 overhaul

1624330 Rake Mechanism Motor

      1624331 clean and adjust controls

      1624332 lubricate bearings

      1624333 replace/rewind motor

      1624334 replace controls

1624340 Channel

      1624341 clean, repair cracks & spalling

1624000 SEWAGE TREATMENT PLANT

1624100 Raw wastewater Pumping

1624110 Centrifugal Pump

    1624111 lubricate bearings

    1624113 replace packing/seals

    1624114 replace coupling

    1624115 replace v-belts

    1624116 disassemble and inspect

    1624117 replace impeller

    1624118 replace bearings

    1624119 overhaul

1624120 Pneumatic Ejector

    1624121 lubricate pilot valve and linkage

    1624122 clean compressor air strainer

    1624123 PM air compressor

    1624124 overhaul air compressor

    1624125 clean and paint

    1624126 overhaul

1624130 Piping

    1624131 flush

    1624132 repair leaks

    1624133 repack valve

    1624134 replace valve

    1624135 replace check valve

    1624136 PM on check valve

1624140 Sewage Pump Motor

    1624141 lubricate bearings

    1624142 replace/rewind

    1624143 clean and adjust controls

    1624144 replace controls

1624200 Comminutation

1624210 Comminutor Motor

    1624211 lubricate bearings

    1624212 replace/rewind motor

APPENDIX B
TASK OUTLINE

1616850   Agitator/Mixer
    1616851   lubricate
    1616852   replace bearings
    1616853   replace eccentric gear
    1616854   repair framing
    1616855   repair blade
    1616856   replace blades
    1616857   overhaul

1616860   Conveyor
    1616861   lubricate
    1616862   replace bearings
    1616863   adjust and align belt
    1616864   repair conveyor belt
    1616865   replace conveyor belt
    1616866   repair framing
    1616867   overhaul

1616870   Motor
    1616871   lubricate
    1616872   replace/rewind

1616880   Slaking Tank
    1616881   clean and paint
    1616882   repair walls and bottom
    1616883   repair baffle
    1616884   replace

1616890   Metering Pump
    1616891   preventive maintenance
    1616893   repair
    1616894   replace

1616730   Adjustable Speed Drive
    1616731   lubricate
    1616732   replace seals
    1616733   replace lubricant
    1616734   overhaul

1616740   Centrifugal Pump
    1616741   lubricate
    1616742   replace seals and packing
    1616743   replace coupling
    1616744   replace v-belts
    1616745   disassemble and check impeller
    1616746   replace impeller
    1616747   replace bearings
    1616748   overhaul

1616800   Chemical Feed System
    1616810   Storage Bin and Cyclone
        1616811   clean and paint
        1616812   repair walls
        1616813   replace
    1616820   Vibrator
        1616821   lubricate
        1616822   replace bearings
        1616823   repair vibrating plate
        1616824   replace plate
    1616830   Screw Dry Chemical Feeder
        1616831   lubricate
        1616832   replace belts
        1616833   replace bearings
        1616834   replace
    1616840   Piping
        1616841   clean and flush
        1616842   repair
        1616843   replace

APPENDIX B
TASK OUTLINE

1616620 Chlorinator
    1616621 clean, inspect and calibrate
    1616622 replace flexible tubing
    1616623 repair leaks
    1616624 replace

1616630 Pressure Reducing Valve
    1616631 clean and adjust
    1616632 replace diaphragm
    1616633 replace

1616640 Automatic Controls
    1616641 clean and calibrate
    1616642 replace

1616650 Injector Booster Pump
    1616651 lubricate
    1616652 replace bearings and packing
    1616653 replace sleeve
    1616654 overhaul

1616700 Sludge Pumping
    1616710 Piping
        1616711 flush piping
        1616712 disassemble and rod out
        1616713 repair leaks
        1616714 repack valves
        1616715 replace valves
        1616716 clean and paint

    1616720 Pump Motor
        1616721 lubricate
        1616722 clean, adjust, and calibrate controls
        1616723 replace controls
        1616724 replace/rewind motor

APPENDIX B
TASK OUTLINE

1616540 Rate Control Valve
    1616541 lubricate and adjust
    1616542 calibrate control
    1616543 repack stem
    1616544 repair
    1616545 replace

1616550 Backwash Pumps
    1616551 lubricate
    1616552 disassemble and inspect
    1616553 replace impeller
    1616554 replace coupling
    1616555 replace shaft
    1616556 repair housin
    1616557 replace seals and packing
    1616558 overhaul

1616560 Surface Wash System
    1616561 repair piping
    1616562 replace piping
    1616563 repair nozzles
    1616564 replace nozzles
    1616565 repair controls
    1616566 replace controls
    1616567 replace

1616570 Pump Motor
    1616571 lubricate
    1616572 replace/rewind

1616600 Chlorination and Flouridation
1616610 Chlorine Injectors
    1616612 replace piping
    1616613 replace jets

APPENDIX B
TASK OUTLINE

1616420 Sludge Collector Mechanism
    1616421 lubricate chain, bearings
    1616422 replace worn or broken flights
    1616423 replace worn or broken chain link
    1616424 replace bearings
    1616425 overhaul
1616430 Sludge Collector Drive
    1616431 replace oil
    1616432 replace shear pin
    1616433 paint
    1616434 replace oil seals
    1616435 overhaul
    1616436 lubricate
1616440 Sludge Collector Drive Motor
    1616441 lubricate bearings
    1616442 replace/rewind motor

1616500 Filtration, Ion Exchange, Activated Carbon
    1616510 Concrete Basin
        1616511 dewater, clean and patch
        1616512 dewater and clean
    1616520 Steel Tank
        1616521 clean and paint
        1616522 repair leaks
    1616530 Underdrain Piping
        1616532 repair leaks
        1616533 repack valves
        1616534 replace valves
        1616535 replace piping

1616230   Mixer

    1616231   lubricate

    1616232   repair mixing blades

    1616233   replace mixing blades

    1616234   replace mixing motor

    1616235   replace mixer

1616300 Flocculation

    1616310   Basin

        1616311 dewater, clean and patch

        1616312 dewater, clean

    1616320   Flocculator

        1616321   lubricate

        1616322   repair paddles

        1616323   replace paddles

        1616324   replace bearings

        1616325   replace v-belts

        1616326   repair variable speed drive

        1616327   replace variable speed drive lubricant

        1616328   replace

    1616330 Flocculator Motor

        1616331   lubricate

        1616332   replace/ rewind

        1616333   clean and adjust controls

        1616334   replace controls

        1616335   replace brushes/bearings

1616400   Clarification

    1616410   Basin

        1616411   dewater, clean, repair cracks & spalling

        1616412   repair baffles

        1616413   replace baffles

        1616414   dewater and clean

APPENDIX B
TASK OUTLINE

<u>1616000 WATER TREATMENT PLANT</u>

  <u>1616100   Pumping</u>

    1616110   Centrifugal Pump

      1616111   lubricate

      1616112 replace coupling

      1616113 replace seals and packing

      1616114 replace v-belts

      1616115 disassemble and inspect impeller

      1616116 replace impeller

      1616117 replace housing

      1616118 replace bearings

      1616119 overhaul

    1616120 Piping

      1616122 repair leaks

      1616123 replace

    1616130 Valves

      1616131 repack

      1616133 replace

    1616140 Pump Motor

      1616141 lubricate

      1616142 replace/rewind

      1616143 clean and adjust controls

      1616144 replace controls

  <u>1616200 Rapid Mixer</u>

    1616210 Chamber

      1616211 dewater and clean

      1616212 repair leaks

      1616213 repair orifice plate

      1616214 replace orifice plate

    1616220 Mixing Tank

      1616221 dewater, clean and repair

      1616222 dewater and clean

1624A84 replace seals and packing

1624A85 replace bearings

1624A86 overhaul pump

<u>1624B00 Aerobic Sludge Digestion</u>

   1624B10   Basin

        1624B11   dewater, clean and repair

        1624B12   dewater and clean

   1624B20   Air Distribution System

        1624B21   disassemble and unclog

        1624B22   repair leaks

        1624B23 replace nozzles

        1624B24   replace piping

   1624B30   Air Compressor

        1624B31   lubricate

        1624B32 clean and check pressure relief valve

        1624B33   replace belts

        1624B34   paint

        1624B35   overhaul

        1624B36   drain, flush, refill oil

   1624640 Compressor Motor

        1624B41. lubricate bearings

        1624B42   replace/rewind

   1624B50 Mechanical Aerator

        1624B51   lubricate

        1624B52 repair/replace impellers

        1624B53   replace bearings

        1624B54   replace coupling

   1624B60 Mechanical Aerator Motor

        1624B61   lubricate bearings

        1624B62 replace/rewind motor

<u>1624C00   Trickling Filter</u>

   1624C10   Retaining Structure

        1624C11   clean and patch structure

1624C12   repair leaks

1624C20 Distributor

    1624C21   lubricate

    1624C22 replace lubricant and adjust guy rods

    1624C23 flush nozzles and laterals

    1624C24 replace nozzles

    1624C25 replace bearings and seals

    1624C26 overhaul

1624C30 Undrain System

    1624C31 flush clean

1624D00 Rotating Biological Contactor (RBC)

1624D10 RBC Motor

    1624D11   lubricate

    1624D12 replace/ rewind

1624D20 Belt Drive

    1624D21   lubricate

    1624D22 replace belts

    1624D23 replace sheaves

1624D30 Gear Reducer

    1624D31   lubricate

    1624D32 replace seals

    1624D33 replace lubricant

    1624D34 overhaul

1624D40 Chain Drive

    1624D41   lubricate

    1624D42 replace lubricant

    1624D43 replace chain and sprockets

    1624D44 replace chain link

    1624D46 overhaul

1624D50 Tank Enclosure

    1624D51 repair leaks

    1624D52 dewater and clean

    1624D53 paint

1624D60 Rotating Plastic Media

    1624D61 lubricate bearings

    1624D62 replace bearings

    1624D63 repair shaft

    1624D64 replace shaft

1624E00 Stabilization Lagoon

    1624E10 Earthen Basin

        1624E11 repair basin walls

        1624E12 dewater and remove solids

    1624E20 Concrete Basin

        1624E21 repair basin walls

        1624E22 dewater and remove solids

    1624E30 Diffused Air Distribution System

        1624E31 remove from tank, inspect and clean

        1624E32 repair leaks

    1624E40 Air Compressor

        1624E41 clean and check pressure relief valve

        1624E42 lubricate bearings

        1624E43 replace belts

        1624E44 paint

        1624E45 overhaul

        1624E46 change lubricant

    1624E50 Compressor Motor

        1624E51 lubricate bearings

        1624E52 replace/rewind motor

    1624E60 Mechanical Aerator

        1624E61 lubricate

        1624E62 repair/replace impellers

        1624E63 replace bearings

        1624E64 replace coupling

    1624E70 Aerator Motor

        1624E71 lubricate bearings

        1624E72 replace/rewind motor

APPENDIX B
TASK OUTLINE

1624F00 Dosing Tank

1624F10 Tank

    1624F11 drain and clean

    1624F12 repair leaks

1624F20 Piping

    1624F21 flush

    1624F22 repair leaks

    1624F23 repack valve

    1624F24 replace valve

    1624F25 replace protective coating on piping and valves

    1624F26 overhaul

1624F30 Counter

    1624F31 clean, oil and adjust

    1624F32 replace

1624G00 Flow Metering

1624G10 V-Notch Weir

    1624G11 clean and level

    1624G12 replace

1624G20 Float and Cable

    1624G21 clean, oil, adjust, and calibrate

    1624G22 replace

1624G30 Sending/Receiving Transmitters

    1624G31 calibrate

    1624G32 replace

1624G40 Totalizer

    1624G41 calibrate

    1624G42 replace

1624G50 Recorder/Indicator

    1624G51 calibrate

    1624G52 replace pen and ink

    1624G53 replace

APPENDIX B
TASK OUTLINE

1624H00   Automatic Sampling

1624H10   Tubing

    1624H11   disassemble and flush

    1624H12   replace

1624H20   Sampler

    1624H21   PM by factory representative

    1624H22   repairs

    1624H23   replace

1624I00   Sand Filtration

1624I10   Backwash Pump

    1624I11   lubricate bearings

    1624I13   replace packing and seals

    1624I14   replace coupling

    1624I15   replace v-belts

    1624I16   disassemble and check impeller

    1624I17   replace impeller

    1624I18   replace bearings

    1624I19   overhaul

1624I20   Pump Motor

    1624I21   lubricate

    1624I22   replace/rewind

1624I30   Automatic Valve Operator and Valve

    1624I32   replace packing

    1624I33   rebuild operator

    1624I34   replace valve

1624I40   Surface Wash System

    1624I41   unclog orifices

    1624I42   replace orifices

    1624I43   repair leaking piping

1624I50   Underdrain System

    1624I52   replace

1624J00 Sludge Drying Bed

    1624J10 Piping/Channels

        1624J11 flush

        1624J12 repair

        1624J13 replace

    1624J20 Basin

        1624J21 clean

        1624J22 repair

    1624J30 Underdrain

        1624J31 flush

        1624J32 repair

        1624J33 replace

    1624J40 Sand

        1624J41 till and relevel

        1624J42 replace

1624K00 Anaerobic Digestor

    1624K10 Tank

        1624K11 empty and clean

        1624K12 repair walls

    1624K20 Tank Cover-Fixed

        1624K21 clean and inspect

        1624K22 repair and patch

    1624K30 Tank Cover-Floating

        1624K31 clean and inspect

        1624K32 repair and patch

        1624K33 renew side skirts

        1624K34 replace

    1624K40 Heat Exchanger

        1624K41 clean tubes

        1624K42 repair tubes

        1624K43 replace tube bundle

        1624K44 repair piping

        1624K45 replace piping

        1624K46 flush piping

1624K47 clean and calibrate temperature controls

1624K49 replace temperature control

1624K4A perform hydrostatic test and certification

1624K50 Pressure and Vacuum Relief Valves

1624K51 clean and check operation

1624K52 replace

1624K60 Flame Arrestor

1624K61 clean and inspect

1624K62 replace

1624K70   Instrumentation

1624K71 clean and calibrate

1624K72 repair

1624K73 replace

1624K80 Condensate Trap

1624K81 clean and inspect

1624K82 repair

1624K83 replace

1624K90 Recirculation Pump

1624K91   lubricate

1624K92 replace impeller

1624K93 replace motor

1624K94 replace pump

1624KA0 Gas Compressor

1624KA1 preventive maintenance, inspection, alignment

1624KA2 repair

1624KA3 replace

1624KB0 Gas Meter

1624KB1 preventative maintenance

1624KB2 repair

1624KB3 replace

1624L00 Vacuum Filtration

    1624L10 Sludge Vat

        1624L11 dewater, clean and inspect

        1624L12 repair

        1624L13 overhaul

    1624L20 Filter Drum

        1624L21 preventive maintenance

        1624L22 repair drum

        1624L23 replace drum

        1624L24 lubricate shaft bearings

        1624L25 replace bearings

        1624L26 repair shaft

        1624L27 replace shaft

    1624L30 Filter Cloth

        1624L31 repair cloth

        1624L32 replace

    1624L40 Agitator

        1624L41 preventive maintenace

        1624L42 repair

        1624L43 replace

    1624L50 Vacuum Pump

        1624L51 lubricate

        1624L52 repair

        1624L53 replace

    1624L60 Filtrate Pump

        1624L61 lubricate

        1624L62 replace seals/packing

        1624L63 replace coupling

        1624L64 replace v-belts

        1624L65 disassemble and check impeller

        1624L66 replace impeller

        1624L67 replace bearings

        1624L68 overhaul

1624L70 Vacuum Control Valve
  1624L71 disassemble,clean and adjust
  1624L72 repair
  1624L73 replace
1624L80 Sludge Cake Conveyor
  1624L81 lubricate
  1624L82 replace bearings
  1624L83 adjust and align belt
  1624L84 repair conveyor belt
  1624L85 replace conveyor belt
  1624L85 repair framing
1624L90 Motor
  1624L91 lubricate
  1624L92 replace/rewind
1624LA0 Variable Speed Drive
  1624LA1 lubricate
  1624LA2 replace lubricant
  1624LA3 replace seals
  1624LA4 overhaul

1624M00 Centrifuge
  1624M10 Rotating Bowl
    1624M11 lubricate
    1624M12 replace bearings
    1624M13 repair bowl walls
    1624M14 overhaul
  1624M20 Rotating Conveyor
    1624M21 preventive maintenance
    1624M22 repair
    1624M23 overhaul
  1624M30 Variable Speed Drive
    1624M31 lubricate
    1624M32 replace lubricant
    1624M33 replace seals

1624M34 overhaul

1624M40 Motor

    1624M41   lubricate

    1624M42 replace/rewind

<u>1624N00 Filter Press</u>

    1624N10 Filter Cloth

        1624N11 repair cloth

        1624N12 replace

    1624N20 Filter Plates

        1624N21 preventive maintenance

        1624N22 repair

        1624N23 replace

    1624N30 Frame

        1624N31 clean and paint

        1624N32 repair

        1624N33 replace

    1624N40 Closing Gear

        1624N41   lubricate

        1624N42 repair

        1624N43 replace gear

        1624N44 overhaul

    1624N50 Motor

        1624N51   lubricate

        1624N52 replace/rewind

    1624N60 Sludge Pump

        1624N61   lubricate

        1624N62 disassemble and inspect

        1624N63 replace impeller

        1624N64 replace motor

        1624N65 replace coupling

        1624N66 overhaul

        1624N67 replace seals/packing

1624N70 Piping

    1624N71 flush

    1624N72 repair leaks

    1624N73 replace

    1624N74 repack valves

    1624N75 replace valves

<u>1624P00 Belt Pressure Filter</u>

    1624P10 Belt

        1624P11 repair belt

        1624P12 replace belt

        1624P13 lubricate drum bearings

        1624P14 replace drum bearings

        1624P15 adjust belt alignment

        1624P16 repair drum

        1624P17 replace drum

        1624P18 overhaul

    1624P20 Scraping Blade

        1624P21 clean and adjust

        1624P22 resurface edge

        1624P23 replace

    1624P30 Drive Mechanism

        1624P31 lubricate

        1624P32 replace lubricant

        1624P33 replace seals

        1624P34 overhaul

    1624P40 Drive Motor

        1624P41 lubricate

        1624P42 replace/rewind motor

Appendix C

INSTRUCTIONS FOR DATA BASE ACCESS

INSTRUCTIONS FOR DATA BASE ACCESS

It is necessary for a potential user of the data base program used here to be thoroughly familiar with the operating system of the computer and be able to load and access D-Base III. Those instructions are beyond the scope of this paper and are better learned from the manuals that accompany the programs.

1. Load D-Base III. From the dot prompt (.) type "DO RN-MAIN". A screen will appear that asks for today's date (Figure C-1). Type in the date using the format month/day/year and hit the return key.

2. The next screen (Figure C-2) will give you four choices for functions to perform and ask you to hit the appropriate number key. If you hit a key that is not a choice, the screen will reappear. A "0" will bring you back to the D-Base dot prompt.

3. If you want to add records, then you hit the "1" key. This action will cause the next screen to appear (Figure C-3). This screen gives you the option of adding records to the area file (1), the system file (2), the subsystem file (3), the task data file (4), or return to the main menu (0) by hitting the appropriate number key. The first three files were created for use by CERL and probably are not of interest. To add input to the task data file, hit the number "4" and the return key.

    a. The next screen (Figure C-4) will ask you if you want to input data

(D), edit (E), or quit (Q). If you hit an "E", the program will put you into the edit mode (see that paragraph for details). If you hit the "Q", the program will bring you back to the previous screen. If you hit the "D", then it will continue in the add mode. Any other key will give you the screen back again.

b. Once you hit the "D" key, the program will ask you for the task code number (Figure C-5). Type in the seven digit number for the task code. The computer will use the first six digits to identify the component and ask you if it is correct (Figure C-6). If you type a "T" for yes it will proceed to the next menu (Figure C-7). If you type an "F" for no, it will go back to the previous menu.

c. If the computer does not find the component in the component file, it will generate a new screen (Figure C-8) that will ask you if you want to add ("A") to the component file, try ("T") another number or quit ("Q") to the main menu. Try will let you try another number and quit will bring you back to the main menu. Add will generate a new screen (Figure C-9) that asks you for the name of the component. When you type it in and hit the return key, the computer will go on with the next screen in the add mode (Figure C-7).

d. The screen shown in Figure C-7 asks you to input data to the task description code field, description of task field and unit of measure field. The task description code field is a code used to identify the task as preventive maintenance (PM), repairs (M/R), or replacement (REPLACE)

FIGURE C-16

Task Code: ____0811102____

Component: __TANK-LESS WATER CLOSET__   System: __SANITARY__   Subsystem: __FIXTURES__
Task Description: __UNPLUG CLOGGED LINE__
Unit of Measure: __M/R__   Frequency of Occurrence: H: __1.33__ A: __1.67__ L: __2.00__
Persons per Team: __1-CT__   Task Duration: __1.391__   Trade: __3__
References: Labor: __1__   Material: __2__   Equipment: __1__

Labor Resources

Subtask Description	Labor Hrs
REMOVE WATER CLOSET, UNPLUG LINE, RESET WATER CLOSET.	1.070

Material Resources

Description	Quantity	Unit Cost	Total Cost	Equiv Labor Hrs
Material	0.00	0.00	1.31	0.0972
	0.00	0.00	0.33	0.0245

SUMMARY

Resources	UOM	Direct	Indirect	Total
Labor	LH	1.070	0.321	1.391
Material	ELH	0.122	0.036	0.158
Equipment	ELH			1.391

Components Containing This Task: _____, _____

Figure C-15

BASIC TASK INFORMATION TABLE

CASES TASK CODE	TASK DESCRIPTION	INDEX NO. TO UNIT OF MEASURE ROW	INDEX NO. TO TRADE	FREQUENCY OF OCCURRENCE			RESOURCES IN EQUIVALENT MAN HOURS		
				High	Average	Low	Labor	Material	Equipment
0811101	REPLACE FLUSH VALVE	1	3	8.0000	10.0000	12.0000	0.1170	0.0133	0.1170
0811102	UNPLUG CLOGGED LINE	1	3	1.3333	1.6667	2.0000	1.3910	0.1582	1.3910
0811103	OVERHAUL FLUSH VALVE	1	3	4.0000	8.0000	6.0000	0.5330	0.0610	0.5330
0811104	REPLACE WATER CLOSET	1	3	20.0000	35.0000	44.0000	2.0280	17.2000	1.0140
0811201	UNPLUG CLOGGED LINE	1	3	1.3333	1.6667	2.0000	1.3910	0.1582	1.3910
0811202	REPLACE WASHER IN BALL COCK	1	3	4.0000	5.0000	6.0000	0.1820	0.0212	0.1820
0811203	REPLACE WORN PARTS IN WATER CLOSET	1	3	13.0000	15.0000	17.0000	1.2090	0.1370	1.2090
0811204	INSTALL GASKET IN SPUD CONNECTION	1	3	17.0000	20.0000	23.0000	0.1300	0.0140	0.1300
0811205	REPLACE WATER CLOSET	1	3	28.0000	35.0000	44.0000	4.1080	24.8139	2.0540
0811301	REPLACE FLUSH VALVE	1	3	6.0000	7.0000	8.0000	0.1170	0.0133	0.1170
0811302	OVERHAUL FLUSH VALVE	1	3	1.0000	1.0000	1.0000	0.5330	0.0610	0.5330
0811303	UNPLUG LINE	1	3	4.0000	5.0000	6.0000	2.1190	0.2398	2.1190
0811304	REPLACE URINAL	1	3	28.0000	35.0000	44.0000	2.1190	30.3292	1.0595
0811401	REPLACE WASHER IN SPUD CONNECTION	1	3	8.0000	7.0000	8.0000	0.1300	0.0140	0.1300
0811402	REPLACE WASHER IN FAUCET	1	3	8.3333	0.5000	0.6667	0.1430	0.0168	0.1430
0811403	REPLACE SUPPORT RODS	1	3	6.0000	7.0000	8.0000	0.2470	0.0274	0.2470
0811404	REPLACE FAUCETS	1	3	4.0000	5.0000	6.0000	0.8190	0.0928	0.8190
0811405	CLEAN OUT STRAINER AND P TRAP	1	3	1.6667	2.0000	2.3333	0.4810	0.0540	0.4810
0811406	REPLACE LAVATORY	1	3	30.0000	40.0000	50.0000	2.0020	5.6311	1.0010
0811501	REPLACE WASHER IN SPUD CONNECTION	1	3	8.0000	7.0000	8.0000	0.1300	0.0140	0.1300
0811502	REPLACE WASHER IN FAUCET	1	3	0.3333	0.5000	0.6667	0.1430	0.0168	0.1430
0811503	REPLACE SUPPORT RODS	1	3	6.0000	7.0000	8.0000	0.2470	0.0274	0.2470
0811504	REPLACE FAUCETS	1	3	4.0000	5.0000	6.0000	0.8190	0.0928	0.8190
0811505	CLEAN OUT STRAINER AND P TRAP	1	3	1.6667	2.0000	2.3333	0.4810	0.0540	0.4810
0811506	REPLACE LAVATORY	1	3	28.0000	35.0000	44.0000	2.0020	11.6158	1.0010
0811601	REPLACE WASHER IN SPUD CONNECTION	1	3	6.0000	7.0000	8.0000	0.1300	0.0140	0.1300
0811602	REPLACE WASHER IN FAUCET	1	3	0.3333	0.5000	0.6667	0.1430	0.0168	0.1430
0811603	REPLACE SUPPORT RODS	1	3	6.0000	7.0000	8.0000	0.2470	0.0274	0.2470
0811604	REPLACE FAUCETS	1	3	4.0000	5.0000	6.0000	0.8190	0.0928	0.8190
0811605	CLEAN OUT STRAINER AND P TRAP	1	3	1.6667	2.0000	2.3333	0.4810	0.0540	0.4810
0811606	REPLACE LAVATORY	1	3	20.0000	35.0000	44.0000	1.0300	0.0140	1.0300
0811701	INSPECT/CLEAN SHOWER HEAD	1	3	1.6667	2.0000	2.3333	0.1170	0.0133	0.1170
0811702	REPLACE FAUCET WASHER	1	3	1.0000	1.0000	1.0000	0.1430	0.0168	0.1430
0811703	REPLACE FAUCETS	1	3	4.0000	5.0000	6.0000	0.8190	0.0928	0.8190
0811704	RESEAL	1	3	8.5000	10.0000	11.5000	0.7670	0.0875	0.7670
0811705	REPAIR DIVERTER VALVE	1	3	3.5000	4.0000	4.5000	1.0270	0.1158	1.0270
0811706	UNSTOP	1	3	1.6667	2.0000	2.3333	0.5720	0.0654	0.5720
0811707	REPLACE TUB	1	3	26.0000	35.0000	44.0000	3.3410	15.6078	1.0705
0811801	INSPECT/CLEAN SHOWER HEAD	1	3	1.6667	2.0000	2.3333	0.1170	0.0133	0.1170
0811802	REPLACE FAUCET WASHER	1	3	1.0000	1.0000	1.0000	0.1430	0.0168	0.1430
0811803	REPLACE FAUCETS	1	3	4.0000	5.0000	6.0000	0.8190	0.0928	0.8190
0811804	RESEAL	1	3	8.5000	10.0000	11.5000	0.7670	0.0875	0.7670
0811805	REPAIR DIVERTER VALVE	1	3	3.5000	4.0000	3.0000	1.0270	0.1158	1.0270
0811806	UNSTOP	1	3	1.6667	2.0000	2.3333	0.5720	0.0654	0.5720
0811807	REPLACE TUB	1	3	26.0000	35.0000	44.0000	3.3410	15.6078	1.0705
0811901	INSPECT/CLEAN SHOWER HEAD	1	3	1.6667	2.0000	2.3333	0.1170	0.0133	0.1170
0811902	REPLACE FAUCET WASHER	1	3	0.3333	0.5000	0.6667	0.1430	0.0168	0.1430
0811903	REPLACE FAUCETS	1	3	4.0000	5.0000	6.0000	0.8190	0.0928	0.8190
0811904	RESEAL	1	3	8.5000	10.0000	11.5000	0.7670	0.0875	0.7670
0811905	UNSTOP	1	3	1.6667	2.0000	2.3333	0.5720	0.0654	0.5720
0811906	REPLACE SHOWER	1	3	37.5000	50.0000	62.5000	98.0170	42.9712	49.4585

FIGURE C-14

```
        Basic Task Information Report for:

             1) Water Treatment Plant
             2) Sewage Treatment Plant
             3) Flooring
             4) All
             0) Return to Previous Menu.



Enter Your Selection !
```

FIGURE C-12

```
          Select the Data File You Wish to Use

                    1)    System
                    2)    Sub-System
                    3)    Component
                    4)    Task Data Informtation

                    0)    Return to Previous Menu




                    Enter Your Selection
```

FIGURE C-13

```
          Do you wish to print the:

                    1)    Basic Task Information Table
                    2)    Task Data Form

                    0)    Return to Previous Menu



     Enter your selection.
```

FIGURE C-11

```
FOR TASK CODE 9999999     :

Freq of Occur: H                    Freq A:              Freq L:
Persons per team:                        Trade-
Reference: Labor-                        Reference: Equipment -
                      Reference: Material-
Subtask Description:



Labor Hours:        .
Mtrl-Qu:            .   UnCst:        .   TtMtrCst:        .   EquLbrHr:
Equp-Qu:            .   UnCst:        .   TtMtrCst:        .   EquLbrHr:
% Comp Repl Cost:       .



Compnts Cntng Task:
1st Component:        2nd Component:              3rd Component:
4th Component:        5th Component:
```

FIGURE C-9

```
                     C O M P O N E N T

         Today is   08/07/85
+---------------------------------------------------------------------------+

 Task Code :9999999:
 Compnt Dscr :                                          :




                                    Enter the above requested information.
```

FIGURE C-10

```
 Record No.        432
 NOTES          memo
 TASK_DSCR   .
```

FIGURE C-7

Enter the following information:

Task Description Code
Description of Task
Unit of Measure

FIGURE C-8

T A S K   D A T A   F O R M

08/07/85
+==+

TASK CODE NO :8888888:

Component not found. Enter <A>dd to Component
Data File, <T>ry another number, or <Q>uit to Main Menu.

FIGURE C-5

```
                        T A S K    D A T A    F O R M

                                                              08/07/85
+=================================================================+

  TASK CODE NO   :            :



```

FIGURE C-6

```
                        T A S K    D A T A    F O R M

                                                              08/07/85
+=================================================================+

  TASK CODE NO   :161611Y:
  Component Descr    :CENTRIFUGAL PUMP:








          Is this the right component (T/F)? T

```

FIGURE C-3

```
          Select the Data File you wish to use!

                    1   AREA
                    2   SYSTEM
                    3   SUBSYSTEM
                    4   TASK Data & Calculation

                    0   Return To Main Menu'




Enter your selection!
```

FIGURE C-4

```
                    T A S K    D A T A    F O R M

                                              08/07/85
+==================================================================

TASK CODE NO  :          :






        Enter <D>ata, <E>dit Data, <Q>uit to Main Menu

                         Enter -->
```

FIGURE C-1

```
     * * * * * * * * * * * * * * * * * * * * * * * *
     *   DA CERL Program - WATER & WASTEWATER TREATMENT   *
     *             COMPONENT AND TASK DATA BASE            *
     * * * * * * * * * * * * * * * * * * * * * * * *

                    Enter today's date :

                              /   /
```

FIGURE C-2

```
     * * * * * * * * * * * * * * * * * * * * * * * *
     *   DA CERL Program - WATER & WASTEWATER TREATMENT   *
     *             COMPONENT AND TASK DATA BASE            *
     * * * * * * * * * * * * * * * * * * * * * * * *


            ===> Select one of the following <===

                    0   EXIT to System Menu
                    1   Add Records
                    2   Search/Edit/Delete Records
                    3   Generate Reports
                    4   File Maintenance

            Enter your selection here ?
```

files. The re-index selection does not work and should not be selected. Re-indexing can be done directly from the dot prompt in D-Base.

b. Selection of the backup files option will generate a new screen (Figure C-18) that asks you which file you wish to backup. Note that the task data file has been divided in half because it will not all fit on one floppy disk. Follow the directions to obtain your backup floppy disk. It takes approximately ten minutes for the task data files to be copied.

a. The basic task information table provides columns of a few fields from the task data file for all task codes called. It can be obtained by hitting the "1" key of the screen shown in Figure C-13 which in turn will generate a new screen (Figure C-14). In this screen, the program asks you to select which report you want. Note that flooring is one of the other sections of the CERL project and selection of that choice will not generate any report as that particular file is empty. A sample of the basic information table is shown in Figure C-15.

b. The task data form provides an individual sheet for each task code number. The form is designed to provide the reader with all the pertinent information about any task statement. A sample is provided as Figure C-16. There will be one or two more screens after that shown in Figure C-13 that give you the opportunity to tailor the content of the report depending on your needs. You can get a report with sheets for only one task record, one with all, or one with a portion of the file.

6. File maintenance is an important function that is provided from the main menu. It allows you to back up your files onto floppy disks which can be put in a safe place. If anything were to happen to the hard disk in the computer, your backup copies could be used to replace those files lost. Backup has been done weekly for the CERL project.

a. Select the file maintenance mode by hitting the "4" key in the main menu. This action will generate a new screen (Figure C-17) which asks you if you wish to make backup copies of your files or re-index data

the main menu (Figure C-2) and hit the "2" key. The screen that will be generated (Figure C-12) will ask you which file you wish to use: the system, sub-system, component, or task data information files. Whichever of the files you decide to enter, the next screen will ask you to enter the appropriate number of the record you want. For example, for the task data information file the program needs the seven digit task code number and for the component file the program needs the six digit component number. Refer to Appendices A and B if you do not have the appropriate number.

To revise information in a record, position the cursor over the incorrect information and type over it. The new information is not saved to the disk until the next screen is generated. Until that point you can revise as often as you wish without actually changing the record. But once you go to the next screen, it is necessary to leave the record and re-enter it if you decide the revision was incorrect.

5. Reports can be generated by returning to the main menu (Figure C-2) and hitting the "3" key. This action will call up a menu screen (Figure C-13) for the two types of reports available: basic task information table or a task data form. The format for both of the reports was dictated by CERL for its purposes and requires a 15 inch wide platen printer. It is possible that a program such as "Sidewinder" ,that turns a printed page sideways, could be used since the document produced while 14 inches wide is only 8.5 inches long. Use of such a program was not investigated.

action. The appropriate code should be entered. The description of task entry is self explanatory. The unit of measure field is limited to the following entries: one each (1-CT), per linear foot (1-LF), per square foot (1-SF), and per 1000 linear feet (3-LF).

e. After this information is entered, the next screen appears (Figure C-10). This screen repeats the task description entered previously and has a memo field. The memo field is represented by the word "memo" and is used to document how the estimates were arrived at. To enter the memo field, put the cursor over the word "memo" and hit the control-page down keys in combination. This action will bring up a blank page on which information can be entered, similar to that used in a word processor. When you are finished with the memo field, hit the combination of control - page up keys. Next, hit the page down key to generate the final screen in the add mode (Figure C-11).

f. Entry of information into this screen is self explanatory. It should be noted that much of the information only is entered for the purposes of the CERL project and can be omitted if not necessary for your purposes. Upon completion of this screen, the program will give you the chance to add another record or go back to the main menu.

4. The edit mode allows you to review and revise each record to correct errors and update information. It uses many of the same screens as the add mode, only there is information already entered in each of the fields. For example, in the task data information file edit will call up the screens shown in Figures C-7, C-10, and C-11. To edit a file, start from

FIGURE C-17

```
Do you wish to :

        1)   Make Backup copies of your files?
        2)   Re-index data files?

        0)   Return to Previous Menu?




Enter Your Selection >
```

FIGURE C-18

```
Select the file you wish to back-up:

        1)   Task Data File for >1624964
        2)   System Data File
        3)   Sub-Task Data File
        4)   Component Data File
        5)   Task Data File for <=1624964

        0)   RETURN to Previous Menu

Enter Your Selection >
```

Appendix D

SAMPLE LETTER

THE PENNSYLVANIA STATE UNIVERSITY

212 SACKETT BUILDING

UNIVERSITY PARK, PENNSYLVANIA 16802

College of Engineering

Department of Civil Engineering

February 14, 1985

Robert Olt
Lotepro Corp.
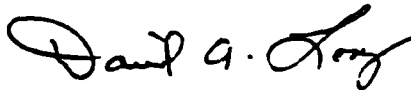1140 Ave of the Americas
New York, NY 10035

Dear Mr. Olt:

Civil Engineering personnel at The Pennsylvania State University are performing a study of water and sewage treatment plants to develop factors to be used in determining annual maintenance and repair costs over the life of a facility. In order to accomplish this task, it is necessary to compile industry accepted standards for maintenance, repair and replacement costs attributable to facilities and equipment normally found in water and sewage treatment plants. It is intended that task statements will be developed for each of the maintenance/repair actions required. Data on the frequency of occurrence and time necessary for completion of a task will be gathered. These data will be used to generate predicted maintenance and repair costs for treatment plants of various sizes.

A second aspect of this study is to review the various management systems used to coordinate maintenance and repair activities. The revolutionary hardware advances recently made in the microcomputer industry have created a strong market for off-the-shelf software packages that can be used to manage the limited resources available for maintenance of facilities. Products and services such as yours are rapidly becoming available and once in place are an indispensable tool for plant managers.

Your firm is being contacted to obtain information on the products and services that you offer and a list of plants that are using any of these products. The principal researcher for this study is Mr. Roland Moreau, an Environmental Engineering graduate student in the Department of Civil Engineering. He can be reached by writing to the above address or by calling 814/865-1226 during afternoon hours. If you have any information that could be of value to him or would like any of your products or services included in the study, please do not hesitate to contact him. All sources of information will be kept confidential if requested.

Your assistance in this matter is greatly appreciated.

Sincerely,

David A. Long, P.E.
Professor of Civil Engineering

DAL/esb

Appendix E

LIST OF ESTIMATING REFERENCES

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1. Model Task Listing from the Yonkers Joint Treatment Plant, Yonkers, New York dated 18 April 1985.

2. Model Task Listing from the New Rochelle Treatment Plant, New Rochelle, New York dated 18 April 1985.

3. Life Cycle Cost Data, by Alphonse J. Dell'Isola and Stephen J. Kirk; McGraw Hill Book Company, 1983.

4. EPS for Machine Shop, Machine Repairs Handbook; Army TB 420-12 dated April 1983.

5. Operations and Maintenance Manual for Sigsbee Park Sewage Treatment Plant, prepared by Briley, Wild & Associates, Inc. dated December 1983.

6. Operations and Maintenance Manual for Boca Chica Sewage Treatment Plant, prepared by Briley, Wild & Associates, Inc. dated December 1983.

7. EPS for Preventive/Recurring Maintenance Handbook; Army TB 420-34 dated March 1984.

8. EPS for Emergency/Service Handbook; Army TB 420-30 dated March 1984.

9. EPS for Pipefitting, Plumbing Handbook; Army TB 420-20 dated August 1983.

10. EPS for Electric, Electronic Handbook; Army TB 420-6 dated February 1982.

11. EPS for Unit Price Standards Handbook; Army TB 420-33 dated August 1983.

12. EPS for Sheet Metal, Structural Iron & Welding Handbook; Army TB 420-24 dated April 1979.

20. Interview of Plant Personnel at Bolten Point Water Treatment Plant, Ithaca, New York.

21. Interview of Plant Personnel of Onondaga County Metropolitan Water Board Water Treatment Plant, Oswego, New York.

22. Interview of Plant Personnel of Pennsylvania State University Wastewater Treatment Plant, University Park, Pennsylvania.

23. Interview of Plant Personnel of University Area Joint Authority Wastewater Treatment Plant, State College, Pennsylvania.

24. Interview of Plant Personnel of Mid Centre Authority Wastewater Treatment Plant, Milesburg, Pennsylvania.

25. Interview of Plant Personnel of Tyrone Regional Wastewater Treatment Plant, Tyrone, Pennsylvania.

30. Authors best engineering judgement.

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